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EP 0332053 A2 US 3821473 A

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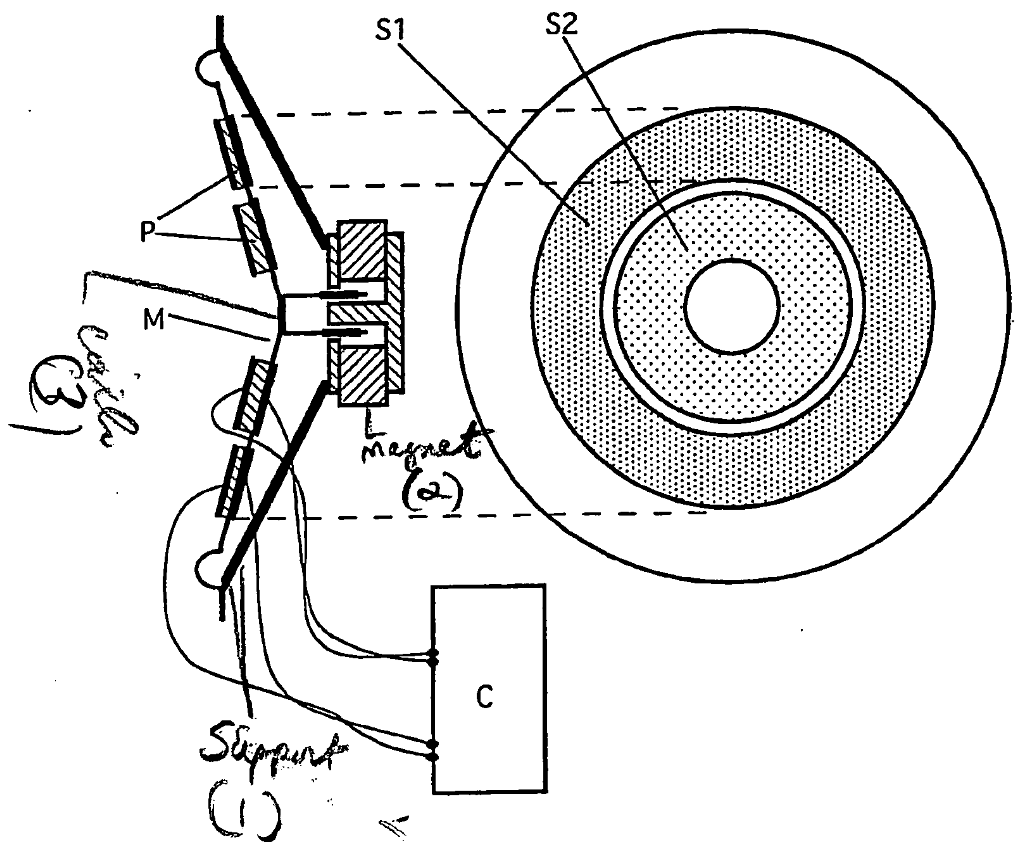
(54) Electrodynamic transducer with integrated pressure sensor

(57) The membrane M of the transducer is covered with piezoelectric material P and conducting coatings forming piezoelectric sensors to measure the gas pressure upon the surface. The piezoelectric material consists of polyvinylidenfluoride, PVDF. The sensors S1, S2 are specially shaped to avoid distortions. They differ in thickness for the elimination of acceleration-dependent signal terms. The transducer is used in loudspeaker systems in which the gas pressure inside the housing is held constant, motional feedback systems and active noise control systems.



FIGUR 1

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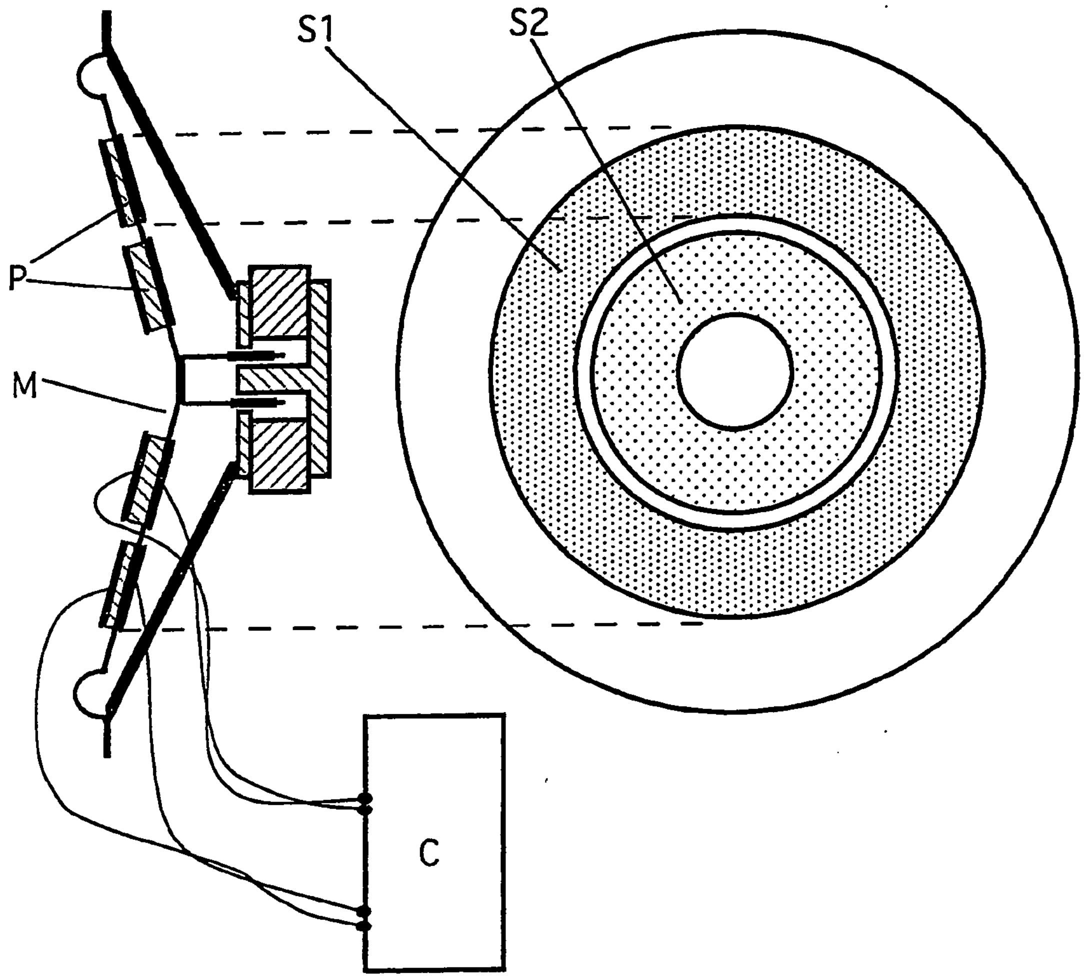

FIGUR 1

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Electrodynamic transducer with integrated pressure sensor.

Description

In some systems which are employed for acoustical sound reproduction sensors are used to measure the produced sound pressure or a gas pressure inside a chamber. The signals generated by these sensors are forwarded to closed loop control circuits which control the sound pressure produced by the loudspeakers or the gas pressure inside the chamber.

Usually these sensors consist of a ceramic piezoelectric material and they are placed at a certain distance from the sound- or pressure producing membrane of a transducer. If these sensors are attached to the moving membrane the acceleration is measured rather than the pressure because of the weight and the resulting inertia of the ceramic material. If the sensors are placed apart from the membrane the resulting dead times, i. e. the time delays in the measurement, impede the proper working of the closed loop control circuits. In addition the sensors, which are attached to the membrane, are relatively small in comparison to the surface of the membrane and so they measure the value just at a certain point of the membrane rather than to give information about an overall value of the whole surface.

The invention according to the claims 1 to 5 circumvents the above described difficulties.

According to claim 1 a thin, flexible coating of piezoelectric material is applied directly to the surface of the membrane, forming an integral part of the membrane. The coating is thin and shaped specifically to avoid the generation of disturbing

signals caused by bending and tension of the membrane. To accomplish this the layer of piezoelectric material is arranged for instance in the form of concentric rings on the membrane´s surface. These concentric rings are separated from each other by thin slits of uncovered areas. Another arrangement would be in the shape of small hexagons of piezoelectric material separated by thin slits.

Claim 2 concerns the usage of piezoelectric polymers for the transducer. Especially the material polyvinylidenfluoride, PVDF, is well-suited for this purpose.

According to claim 3 substantial parts of the membrane´s surface are covered with the piezoelectric material. This will eliminate the distortions of the generated signal caused by resonant waves in the membrane itself.

Claim 4 deals with the task to avoid the generation of signals which are proportional to the acceleration of the piezoelectric material rather than to the pressure upon the surface. For this the piezoelectric layer consists of several areas which differ in their thickness from each other. Each area is equipped with its own electrodes to form independent sensors. The signals generated by the different areas are processed by an electronic circuit. By appropriate multiplication and subtraction of the signals the terms which are acceleration-dependent will eliminate each other. The resulting signal will be mainly proportional to the pressure. If there are two areas with the same size, but the thickness of the one layer is twice the thickness of the other layer, the signal of the thinner sensor must be multiplied by two and the signal of the thicker sensor must be subtracted from the result of the multiplication.

Claim 5 concerns a simple way to arrange the electrodes. They are applied on the two opposite surfaces of the membrane after

it has been coated with the piezoelectric material. Thus the membrane and the piezoelectric layer lie in between the two electrodes. The metalization can be applied by metal vapor deposition.

Claim 6 describes an application of the described transducer in a loudspeaker system with closed housing, in which the pressure is held constant by a closed loop control system. In this kind of system the air pressure in the inner chamber which adjoins the membrane of the outer, sound-radiating loudspeaker is held constant by an inner transducer whose membrane also adjoins the chamber. The claimed transducer is used as this inner transducer. It adjoins the inner chamber with its membrane whose surface is covered with piezoelectric material. The signal generated by the piezoelectric sensors indicate pressure changes in the inner chamber. This signal is forwarded to a controller which drives a power amplifier. The output current of the amplifier drives the inner transducer and displaces its membrane to eliminate pressure changes.

Claim 7 concerns the application of the claimed electrodynamic transducer in a servo controlled loudspeaker system as loudspeaker to produce acoustical waves. The piezoelectric sensors on the surface of the membrane measure the gas pressure on the surface and generate a proportional signal. This signal is forwarded to the controller of the closed loop system which regulates the movement of the transducer´s membrane.

Claim 8 concerns the application of the transducer in noise absorbing and reducing systems. By combining the transducer with a controller and a power amplifier the membrane is displaced to reduce noise. The signal generated by the sensors is forwarded to the controller which steers the amplifier.

Description of the drawing.

Figure 1 shows the claimed transducer. The transducer´s membrane M is covered by two concentric rings of piezoelectric material P. These layers are covered by conducting coatings to form two sensors S1 and S2. The piezoelectric material and the membrane lie in between the conducting coatings. The thicknesses of the two layers differ from each other. The signals generated by the sensors are forwarded via wires to the measuring and calculating circuit C.

Claims

1.) Electrodynamic transducer similar to an elektro-dynamic loudspeaker, consisting of a stiff membrane, which is deplaced by an electrical coil interacting with a magnetic field of a magnet, if an electrical current is applied, characterized by the claimed facts, that parts of one or both surfaces of the membrane are covered with layers of piezoelectric material, that the outer surfaces of these piezoelectric layers and their inner surfaces, adjoining to the membrane, are coated with layers of electrically conducting material to act as electrodes in a way, that the piezoelectric material lies between the electrodes and pressure changes upon the piezoelectric layers generate electrical voltages between the electrodes, that the piezoelectric and conductive layers are made so thin and flexible or shaped by slits in a way, that the driving forces of the coil upon the membrane are transmitted across the membrane via the membrane itself and not via the piezoelectric layer to ensure that the forces which act upon the piezoelectric layers are mainly pressure forces perpendicular to the surface.

2.) Electrodynamic transducer according to claim 1, characterized by the claimed fact, that the piezoelectric layers consist of the material polyvinylidenfluorid, PVDF, or other piezoelectric polymers.

3.) Electrodynamic transducer according to one or more of the previous claims, characterized by the claimed fact, that one or both surfaces of the membrane are almost completely covered by the piezoelectric layers .

4.) Electrodynamic transducer according to one or more of the previous claims, equipped with an electronic circuit to measure the voltages of the piezoelectric elements, characterized by the claimed facts, that the piezoelectric layers of the transducer are arranged as several segments on the surface or that two or more layers are piled on each other, that these layers differ from each other in thickness, that each segment or layer in the pile is equipped with individual conducting electrodes to form individual piezoelectric elements, and that the voltages generated by the piezoelectric elements are multiplied, added and subtracted by an electronic circuit in such a way, that those parts of the signal, which are caused by the elements´ inertia and which are proportional to the acceleration, eliminate each other and that the resulting signal is mainly proportional to the pressure acting upon the piezoelectric layers.

5. Electrodynamic transducer with piezoelectric layers according to one or more of the previous claims, characterized by the claimed fact, that one electrode covers the surface of the piezoelectric layer, and that the other electrode covers the membrane´s surface opposite of the piezoelectric layer in a way, that the membrane and the piezoelectric layer lie both in between the two electrodes.

6. Application of the transducer according to one or more of the previous claims in loudspeaker systems with closed housings, in which the gas pressure inside the housing is kept constant by a closed loop control system working with a electrodynamic transducer inside the housing, characterized by the claimed fact, that the transducer, whose membrane is covered with piezoelectric elements, is used as inner transducer, that the piezoelectric layer on the surface the transducer´s membrane adjoins the inner chamber in which the gas pressure is kept

constant in such a way, that the voltages generated by the piezoelectric elements are proportional to the pressure changes in this inner chamber, that these voltages are forwarded to the controller of the closed loop system, and that the membrane of this inner transducer is deplaced by the electrical current produced by the control´s loop power amplifier in order to keep the pressure constant.

7. Application of the transducer according to one or more of the previous claims in a servo controlled loudspeaker system, in which the sound pressure is servo controlled by a closed loop control system, characterized by the claimed facts, that the electrodynamic transducer, whose membrane is covered with a piezoelectric layer, is used as loudspeaker to radiate acoustical waves, that the piezoelectric layer of the transducer adjoins the space in which the sound is radiated, and that the voltage generated by the piezoelectric elements is forwarded to the controller of the servo system as a signal indicating the produced sound pressure.

8. Application of the transducer according to one or more of the previous claims in noise absorbing systems, in which noise is eliminated by the movement of a transducer´s membrane, characterized by the claimed facts, that the transducer is placed with its piezoelectric sensors adjoining to the place where the noice should be absorbed, that the signal generated by the piezoelectric sensors is forwarded to the noise-absorbing system´s controller, and that the transducer´s membrane is moved by the current of a power amplifier steered by the controller to eliminate noise.

Patents Act 1977
xaminer's report to the Comptroller under Section 17 (The Search Report)

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Relevant Technical fields

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(ii) Int Cl (Edition 5) H04R 3/00, 3/08, 7/00, 7/02, 7/06, 7/10, 7/12

Search Examiner

P J EASTERFIELD

Databases (see over)

(i) UK Patent Office

(ii) ONLINE DATABASES: WPI

Date of Search

7 APRIL 1993

Documents considered relevant following a search in respect of claims 1-8

Category (see over)	Identity of document and relevant passages	Relevant to claim(s)
A	EP 0332053 A2 (YAMAHA) See Figure 15	
X	US 3821473 A (MULLINS) See column 4 lines 51-63	1, 7

Category	Identity of document and relevant passages	Relevant to claim(s)

Categories of documents

X: Document indicating lack of novelty or of inventive step.

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P: Document published on or after the declared priority date but before the filing date of the present application.

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